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OECD Imports

Diversification of Suppliers and Quality Search

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Abstract

This paper explores the evolution of OECD imports over time, measuring their concentration across origin countries at the product level. The authors find evidence of diversification followed, in the very last years of the sample period (post-2000), by a slight re-concentration. This re-concentration is entirely explained by the growing importance of Chinese products in OECD imports. They also find evidence of relatively more volatile concentration levels for goods with high quality heterogeneity, with temporary phases of re-concentration on goods with higher unit values. Both findings are consistent with a simple model of adverse selection and quality screening by OECD buyers predicting that diversification happens by "bouts" rather than continuously, with temporary re-concentration on higher-quality suppliers.

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OECD Imports: Diversification of suppliers and quality search*

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JEL classification codes: F1, O11

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1. Introduction

In spite of the rapid growth of emerging markets, OECD markets are still, today, the world's largest, providing key outlets for goods exported from developing countries. How much access there is for developing countries on OECD markets has been the subject of considerable attention from a policy angle (see e.g. Kee, Nicita and Olarreaga 2009 and references therein). By contrast, to our knowledge, not much has been written on the outcome—the overall evolution and composition of OECD imports. Yet, it matters whether they are opening up in the sense of letting more extra-OECD exporters in, or concentrating on a few "preferred" suppliers. Contestable OECD markets would make it easier for entrants to get a foothold; on the contrary, if they exhibited strong incumbency advantages, they could create a two-track world among extra-OECD exporters (between countries that make it and countries that don't).

So far, a rapidly expanding literature has looked at the other side of the story, namely how export diversification (geographical and product-wise) interacts with economic development. Most of the literature has looked at product-wise diversification. Klinger and Lederman (2004) studied the rate at which new products (defined at the HS4 or HS6 level) appear in a country's export portfolio, and found that it varies with economic development and peaks at middle income levels. Hummels and Klenow (2005) introduced a decomposition of cross-country export variation into intensive and extensive margins that takes account of the economic significance of the goods.[1] They showed that about 60% of the larger export volumes of the larger economies to typical markets is explained by the extensive margin. Cadot, Carrère and Strauss-Kahn (2007) showed that product diversification (measured by Herfindahl, Theil and Gini indices) evolves with income levels in a non-monotone way, with diversification

[1] Hummels and Klenow (2005, henceforth HK) define the intensive margin as the share of country *i*'s exports value of good *k* in the world's exports of that good. That is, country *i*'s intensive margin is its market share in what it exports. The extensive margin is defined as the share, in world exports, of those goods that country *i* exports (irrespective of how much *i* itself exports of those goods). That is, it indicates how much the goods which *i* exports count in world trade. By HK's definition, a country that exports cars and computers will have a larger extensive margin than a country that exports carrots and potatoes, although both export just two goods.

followed by re-concentration beyond income levels around $20'000 at PPP, a pattern similar to what Imbs and Wacziarg (2003) found for production. Hausmann, Hwang and Rodrik (2005) found that export diversification (instrumented) correlates with future income levels, and, moreover, that the similarity of a country's export portfolio with that of the U.S. reinforces the effect on income.

A second, smaller strand of the literature has looked at the extensive margin defined geographically instead of product-wise. The first paper in that vein was Evenett and Venables (2002), who showed, on the basis of evidence for a limited set of developing countries, that about one third of the export growth observed during their sample period came from the expansion of existing exports to new markets. They found that the product-wise extensive margin accounted for only a small fraction of within-country export growth.[2] On the basis of a larger sample, Brenton and Newfarmer (2007) found that the extensive margin accounted for only 19.6% of export growth; of that, 92% came from the export of existing products to new markets.

Another, time-honored strand of the trade literature, going back to the work of Hanson (1996), has emphasized the formation of regional production networks by multinational firms. According to this literature, a country's exports may be determined by the outsourcing decisions of multinationals based in other countries. Anecdotal evidence also suggests that it is retailers who decide which foreign suppliers (and hence countries) are included in cross-border supply chains. Thus, for producers located in developing countries, export opportunities are, at least partly, driven by the policies of large buyers in OECD countries. If those buyers decide to concentrate on a few suppliers in order, say, to simplify logistics or quality-control processes, opportunities will be fewer for entrants at every level of productivity and trade costs. Put differently, given the continued importance of OECD markets for developing-country exports, it seems difficult to understand how developing-country exports evolve without looking at how OECD imports evolve. This is what we set out to do in this paper.

[2] As shown by Hummels and Klenow once the extensive margin is corrected for the importance of the new exports introduced, this result (the relative unimportance of the extensive margin) is reversed

Using a very large database of OECD imports at the SITC4 level since 1963, we find that, up to the turn of the century, OECD markets have been diversifying their sources of supplies (geographically) at the product level. This is reflected in decreasing concentration indices and a rising number of export sources. However, the trend in concentration has reversed itself in recent years. We show that this trend reversal is entirely explained by the rising share of Chinese products in OECD imports, as concentration indices keep on decreasing monotonically when China is excluded. We also find that the pattern of import diversification at the product level is broadly consistent with a simple model where buyers screen suppliers for quality and toss them out when they under-perform. The model predicts that diversification happens by "bouts", or temporary episodes, during which OECD buyers search for high-quality suppliers. Each diversification episode is followed by a phase of re-concentration on the best performers, until those fail (which happens stochastically), triggering new search phases. The model is a very simple, finite-horizon version of a classic two-arm bandit problem. It is close in spirit to Jaud (2011) who also uses a multi-arm bandit setup to explore the effect of tightening standards on purchase volumes.

We test the model's basic prediction by looking at the evolution of unit values during re-concentration episodes and at how the volatility of concentration indices varies across products types, taking the variation in unit values as a proxy for quality heterogeneity. We find, as predicted by the model, that re-concentration, when it happens, is associated with a *rise* in unit values. That is, when buyers re-concentrate, they do so on higher-priced (and hence presumably higher-quality) suppliers rather than on the most price-competitive. We also find that concentration indices are more volatile, over time, for products whose quality (as proxied by unit values) is more heterogeneous across suppliers.

The paper is organized as follows. Section 2 analyses the overall trend in OECD import concentration. Section 3 and 4 set up a simple model of supplier screening in the presence of adverse selection. Section 5 explores empirically the model's implications for patterns of concentration and diversification.

2. Measuring geographical import concentration

2.1 Indices and data

We measure, product by product, the geographical concentration of imports across origin countries. Our measures are standard ones: Herfindahl and Theil.[3] The Herfindahl index for good *k*, normalized to range between zero and one, is

$$H_{kt}^{*} = \frac{\sum_i \left(s_{kt}^i\right)^2 - 1/n_k}{1 - 1/n_k} \qquad (1)$$

where $s_{kt}^i = x_{kt}^i / x_{kt}$ is the share of origin country *i* in OECD imports of product *k* at time *t* and n_k is the total number of countries with the capability to export good *k*. Our baseline definition of the set of potential exporters, n_k, which is time-invariant, is the simplest one: it is the set of all countries having exported good *k* to *some* destination in the world (not necessarily OECD countries) at least two years in a row over the sample period. We impose the requirement of two consecutive years of exports instead of just one in order to ensure that the exporter is a successful one (Besedes and Prusa 2006a, 2006b show that two years is the median duration of export spells; only one year might signal failure rather than the capacity to export). This definition has the advantage of being time- and importer-invariant (the latter matters for the part of our analysis where we disaggregate OECD imports by importing country).

Theil's entropy index (Theil 1972) is given by

[3] We decided not to use Gini coefficient because of the issues associated with this concentration index. The Gini coefficient is a numerical representation of the degree of concentration and represents the distance between the Lorentz curve and the 45° line (egalitarian distribution). There are two issues with Gini coefficients. First, they place more weight on changes in the middle part of the distribution. If a transfer occurs from a larger number of exporters to a smaller number of exporters, it has a greater effect on the Gini if these numbers of exporters are near the middle rather than at the extremes of the distribution. Second, if the Lorentz curves cross, it is impossible to summarize the distribution in a single statistic without introducing value judgements. While studying concentration of import across time these issue should be relevant. Herfindahl and Theil indices are robust to these sensitivity issues [on this, see Sen (1997)].

$$T_{kt} = \frac{1}{n_k} \sum_{i=1}^{n_k} \frac{x_{kt}^i}{\mu_{kt}} \ln\left(\frac{x_{kt}^i}{\mu_{kt}}\right) \quad \text{where} \quad \mu_{kt} = \frac{1}{n_k} \sum_{i=1}^{n_k} x_{kt}^i \tag{2}$$

In order to explore action at the extensive margin, we also consider the simple number of exporters of good *k* to OECD countries.

Our data are COMTRADE import data for OECD countries (either taken as a bloc or disaggregated by importer) at the product level. Our preferred product classifications are SITC4. The alternative, HS6, is more disaggregated (with 4,990 to 5,016 lines depending on the year against 1,158 to 1,300 for SITC4), but the sample period is longer with SITC4, which also underwent fewer revisions. In terms of country coverage, SITC4 data covers 210 countries between 1962 and 2006 (44 years); HS6 coverage is nominally available starting 1988, but with only 12 countries (9 of which are OECD members) expanding gradually to 116 countries in 1995 and 140 in 2006. Descriptive statistics for our sample are shown for our indices in Table 1.

Table 1
Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
n_k	54030	144	53	12	253
All exporters					
n_k^{OECD}	54030	57	35	1	223
Herfindahl	54030	0.19	0.13	0.03	1
Theil	54030	2.68	0.48	0.86	4.87
Extra-OECD exports only					
n_k^{OECD}	53769	35	31	1	194
Herfindahl	53769	0.35	0.22	0.03	1
Theil	53769	3.05	0.60	0.13	5.30

Note: All variables are defined at the product (SITC4) level. The number of observations should be interpreted as follows: The number of potential exporters of good *k*, n_k, is observed for each of 1'034 products and each year, even though its value is, by construction, constant across years.

2.2 Intensive and extensive margins: Prima-facie evidence

Figure 1 shows the evolution of simple averages over all products of our two concentration indices (Herfindahl and Theil) expressed as indices relative to the sample's initial year. That is, for Herfindahl, Figure 1 shows

$$H_t = 100\bar{H}_t / \bar{H}_0 \qquad (3)$$

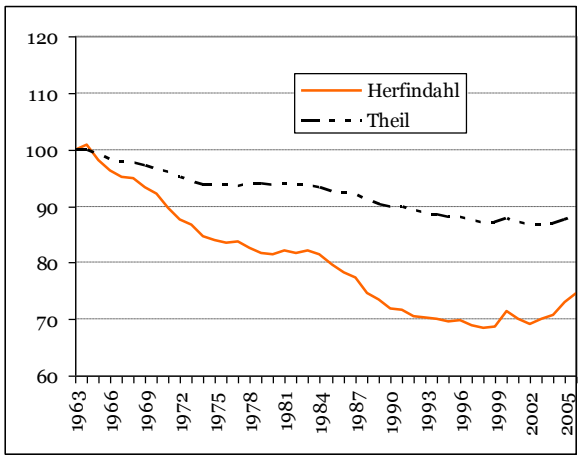
where $\bar{H}_t = \sum_{k=1}^{m_t} H_{kt} / m_t$ is the simple average, for year *t*, of the Herfindahl indices calculated for all m_t goods *k* imported by OECD countries at *t*. The calculation is the same for the Theil index.

Panel a) shows concentration indices calculated using all OECD imports (i.e. imports from all partners, including intra-OECD ones). A strong diversification trend is shown by both indices until 1999 (Herfindahl) and 2002 (Theil), after which both rise until 2006, the sample's last year (by 8.6% for Herfindahl and 1.5% for Theil). Panel b) shows concentration indices calculated using only extra-OECD partners (i.e. developing countries). Both Herfindahl and Theil indices decrease until 1990 (modestly for Theil, which goes down by about 10% over the period) and then go up. Between 1999 and 2006, the Theil index rises by 7.4%, almost three times its coefficient of variation over the period 1963-99.

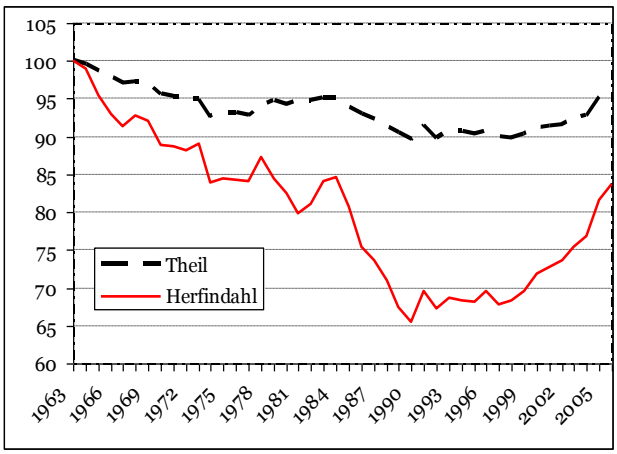
The trend reversal is unmistakable as far as imports from non-OECD countries are concerned. However, it takes place quite late in the sample period. In order to verify whether it is statistically significant, and that it is not a pure composition effect between products (i.e. a sectoral shift away from widely-procured products toward narrowly-procured ones), we now turn to regressions of concentration indices on time and its square using fixed (product) effects. Results are shown in Table 2. Columns (1)-(2) show results with concentration indices (the dependent variable) calculated over all imports (including intra-OECD) whereas columns (3)-(4) show results for extra-OECD imports only (a more interesting measure from a developmental perspective). The within estimator confirms the convex time trend, as both time and its square are significant with opposite signs.

Figure 1
OECD import concentration, 1963-2006

All imports



Extra-OECD imports only



Note: base 100, 1963; simple averages of indices over all products. Data from COMTRADE

As for the extensive margin, Figure 2 shows the evolution of simple and import-weighted averages, across SITC4 lines, of the number of exporters to the OECD over the sample period.

Table 2
Regression results, OECD import concentration on time trend

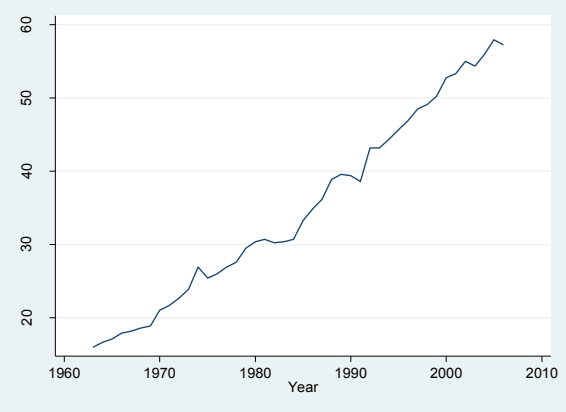
	All imports		Extra-OECD imports only	
	(1)	(2)	(3)	(4)
Regressors:	Herfindahl	Theil	Herfindahl	Theil
time	-0.002***	-0.013***	-0.007***	-0.023***
	(-13.19)	(-34.03)	(-31.80)	(-43.53)
timesq	0.000	0.000***	0.000***	0.000***
	(1.616)	(4.723)	(23.17)	(28.13)
Constant	0.218***	2.913***	0.425***	3.330***
	(202.6)	(861.4)	(221.1)	(686.9)
Observations	54030	54030	53769	53769
Number of index	1301	1301	1301	1301
R-squared	0.571	0.671	0.510	0.570
turning point	2001	2001	1993	1997
Product FE	yes	yes	yes	yes

Notes: t statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

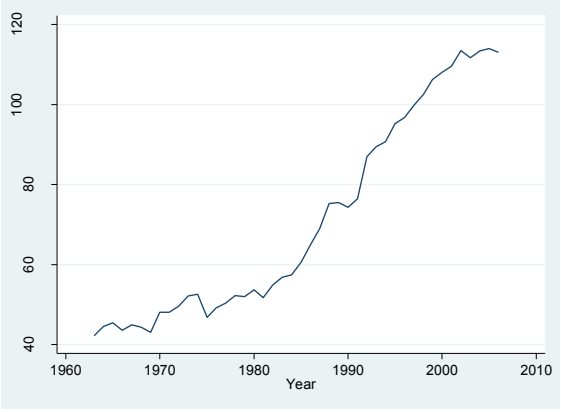
The extensive margin as measured by the average number of source countries does not seem to show the same kind of trend reversal that we observed in the concentration indices, which pick up action at both the extensive and intensive

margins. Simple averages of the average number of OECD suppliers by SITC4 product category are rising monotonically over time.[4]

Figure 2
Average number of exporters to OECD, 1963-2006
Extra-OECD suppliers only[5]
(a) Simple average



(b) Import-weighted average



Note:
a/ Simple averages of number of exporters to OECD at the product (SITC4) level.
b/ Import-weighted averages (weights = shares of each SITC4 product in OECD imports in given year)

Import-weighted averages are leveling out after 2000, but this is not very surprising. The numbers on the vertical axis show that on a trade-weighted basis, the average number of suppliers per product was over 100. For many products, this is likely to exhaust the pool of potential exporters, so a leveling off is to be expected.

Table 3 reports the results of pooled and fixed-effects regressions of the number of exporters to the OECD on time, its square, and a specific time trend for the post-2000 period.

In the latter period, as expected from Figure 2, there is a decline in the rate of increase in the number of exporters to the OECD. This is reflected by the negative coefficient on Post 2000. This inflexion is however not strong enough to reverse the

[4] Bas and Strauss-Kahn (2010) provide evidence of this increased number of exporters serving the OECD market. Focusing on French firms, they found that the number of imported inputs varieties from developing countries increase in average by 48% over the 1995-2005 period.
[5] Figures including all suppliers are very similar to the one presented here and are available upon request.

trend. The observed re-concentration of OECD imports thus seems to be entirely caused by action at the intensive margin.

Table 3
Regression results, Number of countries exporting to OECD

	(1)	*(2)*	*(3)*	*(4)*
Time	0.662	0.593	0.583	0.543
	(17.18)***	(12.71)***	(38.49)***	(29.66)***
Time, squared	0.008	0.010	0.008	0.009
	(9.19)***	(8.52)***	(24.76)***	(20.79)***
Post 2000		-0.391		-0.228
		(2.63)***		(3.91)***
Constant	15.103	15.481	16.560	16.777
	(40.80)***	(38.99)***	(113.19)***	(107.19)***
Observations	53'770	53'770	53'770	53'770
R-squared	0.17	0.17	0.54	0.55
Number of SITC4			1'301	1'301
Fixed (prod.) effects	no	no	yes	yes

Note: Dependent variable: Number of non-OECD exporters to OECD.
The time variable is an index starting as 1963 = 1. The post-2000 variable is another index starting at 2000 = 1. The panel is unbalanced.

In order to explore further what might be driving the apparent re-concentration of OECD imports, we now decompose OECD imports by importing country and construct a three-dimensional panel whose unit of observation (the basis for the calculation of our concentration indices) is a product imported by an OECD country in a year (a triplet importer × product × year). Looking at things this way allows us to look for another type of composition effects that would work as follows. Suppose that the OECD has two members, *A* and *B*, with *B* sourcing its imports of a given product more narrowly than *A*. A rise in B's share of OECD imports will raise the OECD-wide import concentration index for that product through a pure composition effect, although in our previous regressions this would be a within-product rise in the concentration index. Regression results are shown in Table 4.

Several observations come out of Table 4. First, the re-concentration apparent in the Herfindahl and Theil indices seems robust to the introduction of fixed effects by importer × product pair. The news comes from the extensive margin, where not only the square term on time preserves the mononicity of diversification but even the post-2000 time trend no longer indicates a trend inflexion in the very last years. The

disappearance of the trend inflexion (apparent in Table 3 which included fixed effects by products but not by importing country because the unit of observation was all-OECD imports) suggests that the inflexion resulted from a composition effect between importers as described above.

To sum up, the observed re-concentration of Table 2 is robust to the decomposition of OECD imports by importing country. However, as Tables 3 and 4 show, it does not occur at the extensive margin, all of the action being at the intensive margin.

Table 4
Regression results, OECD import concentration on time trend

Herfindahl

	(1)	*(2)*	*(3)*	*(4)*
Time	-0.010	-0.009	-0.009	-0.007
	(115.74)***	(86.33)***	(140.45)***	(92.51)***
Time, squared	0.000	0.000	0.000	0.000
	(51.13)***	(27.11)***	(41.94)***	(3.42)***
Post 2000		0.005		0.008
		(14.76)***		(39.35)***
Constant	0.807	0.802	0.798	0.789
	(932.13)***	(859.28)***	(1320.17)**	(1216.18)***
Observations	1'154'420	1'154'420	1'154'420	1'154'420
R-squared	0.07	0.07	0.13	0.13
Fixed effects a/	no	no	yes	yes

Theil

	(1)	*(2)*	*(3)*	*(4)*
Time	-0.012	-0.009	-0.019	-0.015
	(63.78)***	(41.27)***	(155.47)***	(100.10)***
Time, squared	0.000	-0.000	0.000	-0.000
	(7.94)***	(7.32)***	(35.37)***	(7.05)***
Post 2000		0.012		0.020
		(19.11)***		(47.64)***
Constant	4.236	4.222	4.358	4.336
	(2336.35)**	(2160.58)**	(3626.10)**	(3363.56)***
Observations	1'154'420	1'154'420	1'154'420	1'154'420
R-squared	0.05	0.05	0.18	0.18
Fixed effects a/	no	no	yes	yes

Number of partners

	(1)	*(2)*	*(3)*	*(4)*
Time	0.093	0.153	0.062	0.091
	(31.30)***	(42.34)***	(40.07)***	(48.33)***
Time, squared	0.003	0.001	0.004	0.003
	(46.90)***	(14.21)***	(129.70)***	(75.63)***
Post 2000		0.305		0.147
		(29.10)***		(27.01)***
Constant	3.259	2.917	3.033	2.871
	(111.72)***	(92.81)***	(196.73)***	(173.47)***
Observations	1'154'420	1'154'420	1'154'420	1'154'420
R-squared	0.09	0.09	0.29	0.29
Fixed effects a/	no	no	yes	yes

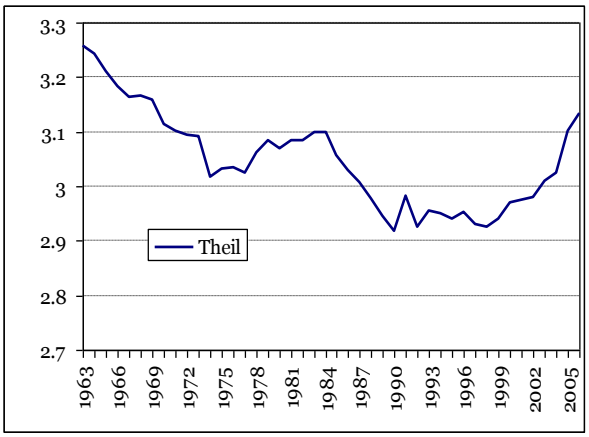
Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
a/ fixed effects by importer × product pair

2.3 The China effect

Considering the rising importance of OECD trade with China over the last decade, we must control for the role that China may play in that re-concentration. Figure 3 shows the evolution of the Theil index for extra-OECD imports, both with and without China. The figures show that China is indeed driving the observed re-concentration. Further evidence is provided in Table 5, which shows that the coefficient on time squared loses its significance when China is excluded from the sample.

Figure 3
Theil index for OECD imports excluding China, 1963-2006

Extra-OECD imports



Extra-OECD imports excluding China

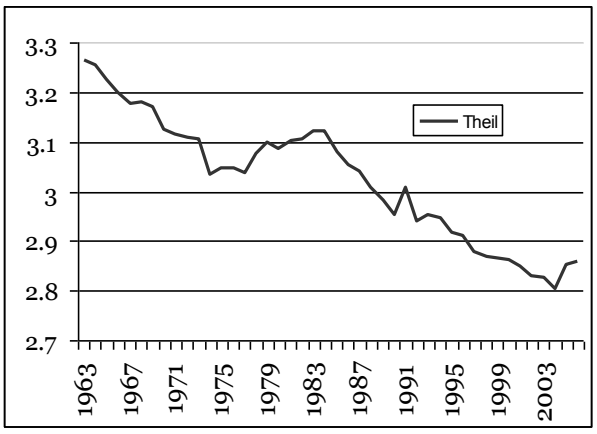


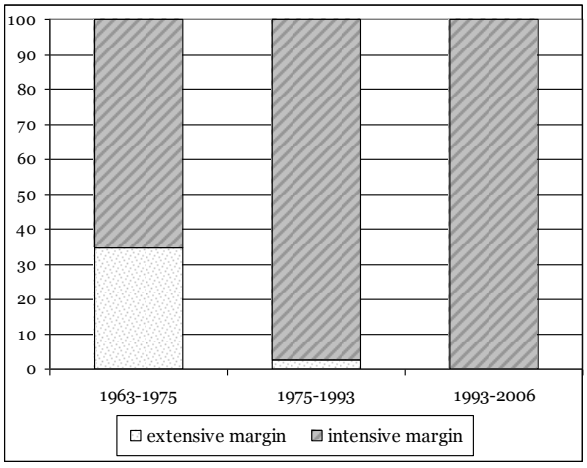
Figure 4 confirms that the increased concentration of OECD imports on China occurs at the intensive margin: In recent years, no new product line opened between China and its OECD trade partners.

Table 5
Regression results, OECD import concentration on time trend, excluding China

Regressors:	Herfindahl	Theil
time	-0.004***	-0.013***
	(-17.08)	(-24.61)
timesq	0.000*	0.000
	(1.925)	(0.0720)
Constant	0.419***	3.302***
	(218.4)	(677.4)
Observations	53763	53763
R-squared	0.531	0.581
Product FE	yes	yes

Notes: t statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

Figure 4
Contribution of the intensive and extensive margin to China-OECD imports growth, 1963-2006



Thus, although their imports are increasingly concentrating on Chinese products, OECD countries continue to open new imports lines with extra-OECD countries. That is, China's expanding exports to the OECD do not seem (yet) to crowd out the entry of new exporter/product pairs on OECD markets.

To sum up, the evidence in this section shows diversification taking place over time, subject to one caveat: China's growing share of OECD imports, which caused a recent re-concentration at the intensive margin. However, the evidence so far does not say what drives this progressive diversification, nor what counter-forces, if any, may be at play, preventing it from being instantaneous. That is, prima-facie evidence does not tell us when the doors of OECD markets open and when they close. We posit that OECD buyers, in search for quality, test suppliers and concentrate on the best. As the set of suppliers expands and buyers continue sampling, diversification takes place. In order to explore this conjecture, we first build up a very simple, stripped-down model of quality search. We then introduce additional assumptions on buyer tastes and expanding supplier pool potentially interfering with the basic quality-search mechanism. Finally, we explore empirically the model's testable implications.

3. A simple model of quality search

3.1 Baseline model

In this section we explore how supplier concentration is affected by informational considerations in the presence of a selection problem. Consider a three-period setting where, in each period, a buyer needs to procure two units of a product from either one or two suppliers called *X* and *Y*. Each supplier has the capacity to provide either one or two units, as the buyer wishes, at a constant price. Suppliers are of unknown quality, with a per-period probability of providing a non-defective product equal to λ^G for a good type and $\lambda^B < \lambda^G$ for a bad type (that is, the arrival of defective products follows an independent Bernoulli process for each supplier). The buyer knows λ^G and λ^B but not the type of each supplier, and assigns a prior probability p_1 on a good type in the initial period. Let π^1 be the buyer's profit on a non-defective product and $\pi^0 < \pi^1$ on a defective one, payoffs being additive, and let $\zeta^i = 1$ designate the event that the product is non-defective. Let

$$\bar{\pi}^G = \lambda^G \pi^1 + \left(1 - \lambda^G\right)\pi^0 \qquad (4)$$

be the expected profit from buying from a good type and similarly for $\bar{\pi}^B$. In periods 2 and 3, the buyer revises his beliefs about the quality of each supplier on the basis of information (defective product or not) he obtained by dealing with them (if he did) in the previous period. Let

$$p_t^i = \frac{\lambda_G p_{t-1}^i}{\lambda_G p_{t-1}^i + \lambda_B \left(1 - p_{t-1}^i\right)}, \quad t = 2,3 \tag{5}$$

be the revised probability that supplier *i* is a good type in *t*, based on information from period *t-1*.

The buyer faces two sequential-sampling (or stopping-time) problems on two independent stochastic processes, but the decisions are not independent because sampling on one has consequences for the optimal stopping time on the other. The problem is thus potentially very complicated, but the limitation to two suppliers and three periods keeps it tractable.[6] Consider the third-period problem, and let V_3 be the buyer's expected profit. Suppose that he dealt with both suppliers in period 2. Then in period 3 he buys both units from the best, so

$$V_3(2) = p_3^* \left(2\bar{\pi}^G\right) + \left(1 - p_3^*\right)\left(2\bar{\pi}^B\right) \tag{6}$$

where

$$p_3^* = \max\left\{p_3^x, p_3^y\right\}$$

is the highest of the two posteriors. If he used just one of them in period 2, *i*, then he just keeps that one and

$$V_3(1) = p_3^i \left(2\bar{\pi}^G\right) + \left(1 - p_3^i\right)\left(2\bar{\pi}^B\right) \tag{7}$$

[6] The problem of selecting the stochastic process that delivers the highest expected reward among a set of independent processes is known in the statistical-decision literature as a "multi-armed bandit" problem. One strategy, called "epsilon-first", consists of a sampling (exploratory) phase during which several "levers" are tried, after which the experimenter sticks to the lever for which he has the most optimistic belief based on information gathered during the sampling phase.

where p_3^i is the revised belief on supplier *i* used in period 2. Clearly, by definition of the max, $V_3(2) \geq V_3(1)$ and the difference, $\Delta V_3 = E\left[V_3(2)\right] - E\left[V_3(1)\right]$, is the value of information generated by keeping both suppliers in period 2.

In period 2, with two suppliers and a discount factor δ,

$$\begin{aligned} V_2(2) = {} & p_2^x p_2^y \left(2\bar{\pi}^G\right) + \left(1-p_2^x\right)\left(1-p_2^y\right)\left(2\bar{\pi}^B\right) \\ & + \left[p_2^x\left(1-p_2^y\right) + p_2^y\left(1-p_2^x\right)\right]\left(\bar{\pi}^G + \bar{\pi}^B\right) + \delta V_3(2). \end{aligned} \tag{8}$$

With one supplier,

$$V_2(1) = p_2^*\left(2\bar{\pi}^G\right) + \left(1-p_2^*\right)\left(2\bar{\pi}^B\right) + \delta V_3(1) \tag{9}$$

where $p_2^* = \max\left\{p_2^x, p_2^y\right\}$.

In period 1, finally, the prior being the same on both suppliers, both are used, generating the information used to revise beliefs from p_1 to p_2^x and p_2^y respectively. Clearly, the "interim" payoff collected in period 2 is higher, in expected value, with one supplier than with two, since in the former case the buyer buys only from the best whereas in the latter he carries both along. However, the expected period-3 payoff is, as noted, higher when two suppliers are kept in period 2 because the information generated has a value. Thus, there is a trade off between concentrating on the most efficient supplier and keeping several in order to "test" them.

What does the value of the information depend on? Suppose that, at the end of period 1, the buyer kept only one supplier, the one with the highest probability of being good, and suppose (without loss of generality) that it was supplier *x*. Letting I_2 stand for the information available at the beginning of period 2, the conditional expectation of the period-3 gain is (see appendix):

$$E\left(V_3 \middle| I_2\right) = 2\left[p_2^x \bar{\pi}^G + \left(1-p_2^x\right)\bar{\pi}^B\right]. \tag{10}$$

Let $\phi^y = \Pr\left(p_3^y > p_3^x \middle| p_2^y < p_2^x\right)$ be the probability that y would perform better than x in period 3, given that he performed worse so far, if we could observe both in action in period 3. Using this, it can be shown that the value of the information is

$$\begin{aligned}\Omega &= \varphi^y\left[E\left(V_3\middle| p_3^y > p_3^x; I_2\right) - E\left(V_3\middle| I_2\right)\right] \\ &= 2\varphi^y\left[E\left(p_3^y\middle| p_3^y > p_3^x\right) - p_2^x\right]\left(\bar{\pi}^G - \bar{\pi}^B\right).\end{aligned} \tag{11}$$

Thus, the value of the information depends on three multiplicative terms. The first is the probability that a good draw for the second-best supplier would reverse the ranking of beliefs. In a three-period model, sampling stops in period one and concentration has to take place.[7] By contrast, with more periods a reversal of beliefs is possible, and so, depending on the parameters (λ and π) continued sampling is optimal. In section 3.1.2 below, a multi-period simulation of the model provides evidence of this phenomenon.

The second term is that in square brackets. Observe that it is decreasing in p_2^x; the better is the "front-runner" supplier (x) the less there is to gain from an eventual reversal of beliefs. In our 3-period setting, this doesn't say much, but in a multi-period setting it would have a potentially important consequence on which we will return.

The third term, finally, is the difference in expected gains between a good and a bad supplier, which can be written as

---

[7] In our three-period model, the event that $p_2^y < p_2^x$ implies that y had a defect in period 1 while x did not. Then, if fortunes are reversed in period 2 (x has a defect while y has not), it is easily verified that posteriors at the beginning of period 3 will be just equal for x and y. So, at best, the buyer will be indifferent between x and y in period 3. In(11), we have thus $\phi^y = 0$ and, given the multiplicative form of Ω, the value of the information is nil: There is no reason to keep on sampling after period 1. In a 4-period framework, at the cost of tedious algebra it is (relatively) straightforward to show that a reversal of beliefs is possible with two successive lucky draws on y and two unlucky ones on x, and so, continued sampling (using both suppliers) can be optimal in period 2.

$$\bar{\pi}^G - \bar{\pi}^B = \left(\lambda^G - \lambda^B\right)\left(\pi^1 - \pi^0\right). \qquad (12)$$

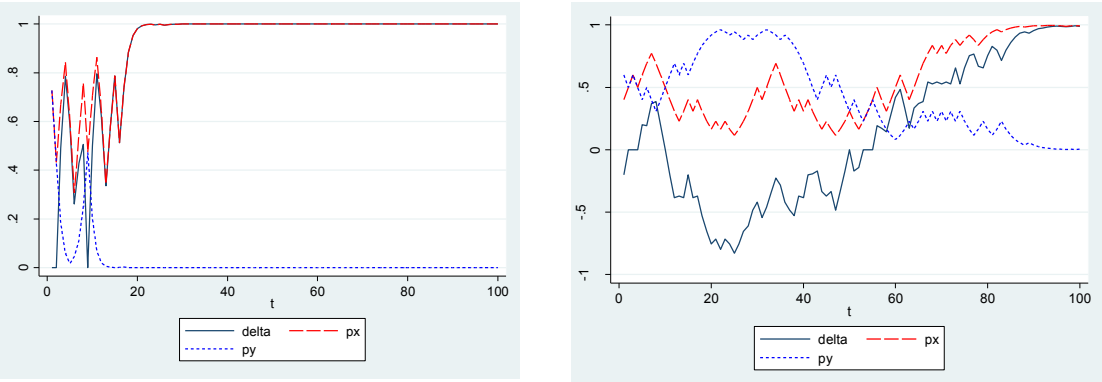
The first factor on the RHS of (13) is the difference between the prospects of a good and a bad supplier, a measure of their heterogeneity; the second is the effect of quality differences on profit, a measure of the industry's characteristics (quality-sensitivity). Thus, the value of information, which in our setting drives the search for quality, is increasing in their heterogeneity and in the sensitivity of buyers to product quality.

3.2 More than three periods

With more periods, the revision of beliefs (i.e. the difference between posterior and prior from one period to the next) becomes smaller over time as beliefs approach asymptotically zero or one, but how fast the process of revision converges depends, of course, on the parameters of the two processes. If the two distributions (good and bad) have similar parameters, it takes, in expectation, more time to tell apart the two types, which requires longer sampling. Figure 5 illustrates how the rate of convergence varies with the parameters. In the LHS panel the two distributions are characterized by sharply different parameters and beliefs converge after twenty periods; in the RHS panel, the two distributions have similar parameters and the beliefs take almost a hundred periods to converge.

Figure 5.
Random draws of Bernoulli processes in two cases

A pair of draws with $\lambda^G = 0.8, \quad \lambda^B = 0.3$ A pair of draws with $\lambda^G = 0.6, \quad \lambda^B = 0.4$



Notes: The dotted blue curve gives p_t^x, the revised probability that x is of the good type; the long-dashed red curve gives same thing for y, and the plain black curve gives the difference between the

two. The same parameters are used to draw the observations and to update the beliefs (parameters are assumed common knowledge); x is of the good type and y of the bad type.

In the LHS case, positions tend to lock in fairly quickly. In the RHS case, longer sampling is needed to tell apart the two suppliers; however, note that the difference in expected returns ($\bar{\pi}^G - \bar{\pi}^B$), which is part of the value of the information, is also smaller, so the truth takes longer to appear but it matters less. Observe also that in the RHS panel, around iteration #20, supplier x has accumulated so many bad draws and supplier y so many good draws that the buyer is "almost certain" that y is of the good type, *even though this belief is false* (observe the dotted curve (y) approaching one between iterations #20 and #40). Going back to (11), we see that

$$\lim_{p_2^x \to 1} \Omega = \lim_{p_2^x \to 1} E\left(p_3^y \middle| p_3^y > p_3^x\right) - p_2^x = 0; \qquad (13)$$

that is, when the buyer becomes "almost certain" that his currently preferred supplier is of the good type, the value of information goes to zero and he stops sampling. If that were the case in the RHS panel of Figure 5 (where the preferred supplier around iteration 20 is y) the part of the red, long-dashed curve lying to the right of the stopping time would be censored. The remaining incumbent (here y) would then be the sole supplier until sufficient evidence accumulates to convince the buyer that he had bet on the wrong horse (in the figure, that becomes clear after about iteration 60 and the posterior on y finally converges to zero around iteration 90). The buyer would turn to the alternative supplier only when his revised opinion on the incumbent drops back below the evicted supplier's last posterior.[8]

The model thus implies that concentration, when it occurs, is on high quality products. It also suggests that periods of diversification are followed by periods of re-

[8] Note that in this setup there can be no "informational cascade". An informational cascade (Bikhshandani et al. 1992) can take place when a sequence of actors make binary decisions on a singe issue (say, buying or selling a stock) based on a noisy signal about the correct decision and on the observed behaviour of past players. Each player forms his own belief based on a weighted average of his signal and past players' actions, with weight on the latter that increases with the number of past players. Bikhshandani et al. show that there exists a critical number n such that, if n players observe the wrong signal and act accordingly, the n+1st will discard his own signal and follow the crowd. From then on, the herd behaviour cannot be reversed. Our setup is different because the buyer is repeatedly getting information about his supplier, whereas in an informational cascade the individual experimenter gets only one signal that he compares with the actions of other (past) players.

concentration—that is, diversification occurs by "bouts". This simple model is however not sufficient to generate the diversification process observed in Section 2. In order to shed light on the forces at works, we add to the model two additional assumptions: (i) buyers have a taste for diversity, and (ii) the number of suppliers is expanding.

4. Quality search with diversification

4.1 Taste for diversity

A taste for diversity can be introduced in the model by replacing the assumption of additive payoffs by a utility function of the form

$$\Pi = \left[\sum\nolimits_i \left(\pi_i \right)^{\alpha} \right]^{1/\alpha} \tag{14}$$

where $\pi_i \in \left\{ \pi^0, \pi^1 \right\}$ is the profit made on the purchase from supplier *i*. To see what happens to the model's basic predictions, consider period 3. The reasoning is similar for earlier periods. The period-3 payoff from using one supplier only (the preferred one), which was previously given by (6), is unchanged. That is,

$$V_3\left(2,1\right) = 2p_3^* \bar{\pi}^G + 2\left(1 - p_3^*\right)\bar{\pi}^B . \tag{15}$$

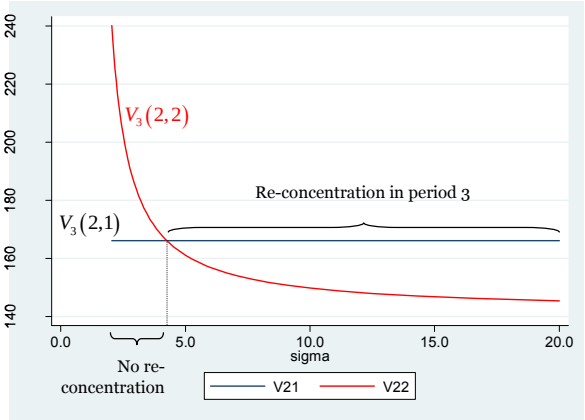
The corresponding payoff if the buyer uses both suppliers in period 3 is

$$\begin{aligned} V_3\left(2,2\right) = p_3^y \left\{ 2p_3^x \bar{\pi}^G + \left(1 - p_3^*\right)\left[\left(\bar{\pi}^G\right)^{\alpha} + \left(\bar{\pi}^B\right)^{\alpha} \right]^{1/\alpha} \right\} \\ + \left(1 - p_3^y\right)\left\{ p_3^x \left[\left(\bar{\pi}^G\right)^{\alpha} + \left(\bar{\pi}^B\right)^{\alpha} \right]^{1/\alpha} + 2\left(1 - p_3^*\right)\bar{\pi}^B \right\} \end{aligned} \tag{16}$$

Suppose, without loss of generality, that the preferred supplier is *x*. Replacing p_3^* by p_3^x in (6), it is easily verified that, for $\alpha = 1$, keeping one supplier is optimal (this is the benchmark case without a taste for diversity). However, as α goes down, the sign of the inequality is eventually reversed and the taste for diversity comes to dominate the selection effect. This is illustrated in Figure 6 where $V_3\left(2,1\right)$ and $V_3\left(2,2\right)$ are shown as functions of $\sigma = 1/\left(1-\alpha\right)$, the elasticity of substitution between the two suppliers,

for assumed parameter values. For values of σ below 4.3, the taste for diversity dominates and keeping both suppliers is optimal; for values above 4.3, the selection effect dominates and keeping only one supplier is optimal.

Figure 6
Period-3 profit from one vs. two suppliers, as a function of the elasticity of substitution



Notes: Simulated parameter values are $\pi 1$=100, $\pi 0$=50, λG=0.8, λB=0.1, $p3x$=0.8, $p3y$=0.1.

What does this mean for our model? Essentially that the taste for diversity acts as a counterforce to the selection effect, generating situations where the Bayesian update of beliefs designates one supplier as preferable to others but the buyer nevertheless keeps several because he values diversity.

4.2 Entry of new suppliers

The number of suppliers would enlarge if trade costs were coming down or if productivity was rising exogenously among producers in a pool of potential suppliers with heterogeneous productivity levels as in Helpman, Melitz and Rubinstein (2008). Several empirical studies evidence this increase in the number of potential suppliers. Cadot et al. (2011) show that, over 1989-2005, on average each country has introduced 50 to 200 new export products. Similarly, using a more restrictive definition of new products, Klinger and Lederman (2004) found that 1710 new product-country pairs were introduced in the 1990s (with a maximum of 160 for

Indonesia).[9] Suppliers would then appear progressively, creating scope for diversification of supplier sources at the extensive margin. As before, the repetition of transactions with incumbents would asymptotically reveal their quality, but strings of bad draws would always be possible even for good types, and their replacement would then set the clock back to zero for the new ones. With several entrants all characterized by similar priors, buyers would start by sampling all of them like at the beginning of our 3-period model, subsequently concentrating on the best. Episodes of diversification would be followed by episodes of concentration.

Thus, informational considerations in the multi-period setup suggest that, in sectors where quality matters and is not standard across suppliers, entrants will find it hard to unseat incumbents as long as those perform well. But, with stochastic quality draws, incumbents are bound to fail one day or another. When they fail sufficiently severely (i.e. with a string of bad draws in a row), a window of opportunity opens up for entrants, ushering in a new phase of diversification, quality search, and ultimate re-concentration on the best performers.[10] With an increasing number of suppliers, the number of best performers chosen as importers increase over time. The buyers' taste for diversity reinforces this effect. There is diversification. What the model shows is that diversification will happen by "bouts", as a result of repeated failures in established buyer-supplier relationships, rather than as a continuous phenomenon.

All in all, our simple model suggests essentially this:

1. Diversification of import sources can be driven by two forces: (a) quality search in the presence of a selection problem; (b) an exogenous taste for diversity.

[9] Note that these studies consider new products at the HS6 level. The number of new producers is obviously much larger.
[10] Failure may also be triggered endogenously by moral hazard if incumbents slacken the monitoring effort as time passes. For a reputational model with both selection and moral hazard, see e.g. Laeven and Perotti (2001).

2. When driven by quality search, diversification is only a temporary phenomenon, as the buyer will, at the end of each search phase, re-concentrate on the best supplier.

3. Incumbent suppliers' established positions will periodically be unseated by strings of bad quality draws, which will trigger the onset of new search phases.

4. With an increasing number of suppliers, new search phases are likely to entail higher diversification over time.

Thus, whereas the taste-for-diversity forces generate maximum diversification at all times (an essentially static prediction), quality search suggests alternating phases of diversification and re-concentration. The existence of these phases is implied only by the informational features of the model. Thus, volatility in concentration levels can be taken as a hallmark of informational phenomena and it depends on the heterogeneity of quality levels across suppliers.[11] This implies two testable propositions:

Proposition 1: When concentration occurs, it occurs on goods of higher quality.

Proposition 2: Time-wise volatility in the concentration of imports is higher for goods that are more heterogeneous in terms of quality.

We now turn to an empirical exploration of these conjectures.

5. Concentration and quality search: Testing for "bouts"

Proposition 1 involves unobservable quality heterogeneity. We approximate quality by unit values, of which we calculate import-weighted averages for each OECD importer, good and year. If re-concentration, when it takes place, is on the best performers, we expect positive year-on-year changes in the Theil index to correlate

[11] However, supply shocks knocking out suppliers periodically could also create exogenous volatility at the extensive margin. This is to be kept in mind in the empirical exploration that follows, as baseline volatility is unlikely to be exactly zero.

with positive changes in the average unit value of imports. The average unit value's rise is a composition effect, as buyers concentrate on high-quality suppliers. Thus, a straightforward test would consist of regressing, on a panel of products or (importer × product) pairs (recall that we are looking at concentration across source countries), first differences in Theil indices on first differences in average unit values across sources, expecting a positive correlation. However, we can sharpen this test using a key corollary.

Table 6
Regression results, change in Theil on change in unit values

Dep. Var	Δ Theil$_{ik(t-(t-1))}$	Δ Theil$_{ik(t-(t-1))}$	Δ Theil$_{ik(t-(t-1))}$	Δ Theil$_{ik(t-(t-1))}$
Regressors	(1)	(2)	(3)	(4)
Δ UV$_{ik(t-(t-1))}$ / (Δ Theil$_{ik(t-(t-1))}$>0)	1.05E-06 **	9.78E-07 *	-	-
	(5.50E-07)	*(5.70E-07)*		
Δ UV$_{ik(t-(t-1))}$ / (Δ Theil$_{ik(t-(t-1))}$<0)	-3.47E-07	-2.04E-07	-	-
	(1.95E-06)	*(2.30E-07)*		
Δ UV$_{ik(t-(t-1))}$ / (Δ Theil$_{ik(t-(t-1))}$>0.1)	-	-	1.45E-06 **	1.43E-06 **
			(7.54E-07)	*(7.42E-07)*
Δ UV$_{ik(t-(t-1))}$ / (Δ Theil$_{ik(t-(t-1))}$<0.1)	-	-	-2.02E-07	-1.56E-07
			(1.48E-07)	*(1.63E-07)*
Observations *(ikt)*	1,059,984	1,059,984	1,059,984	1,059,984
Nber of products *(k)*	1,299	1,299	1,299	1,299
Nber of importers *(i)*	29	29	29	29
Years *(t)*	1963-2006	1963-2006	1963-2006	1963-2006
Observations with Δ Theil>*x*	640,038	640,038	377,294	377,294
Importer × Product Fixed Effects	Yes	-	Yes	-
Importer Fixed Effects	-	Yes	-	Yes
Product fixed effects	-	Yes	-	Yes
Year fixed effects	Yes	Yes	Yes	Yes

Notes: estimation with OLS; standard errors in parentheses: heteroskedasticity-consistent and adjusted for product-level clustering; * : p=0.1, **: p=0.05, ***: p=0.01.

The corollary is that the effect is asymmetric: whereas the model predicts that unit values should rise during *concentration* phases, it is silent on the evolution of unit values during *diversification* phases. At the beginning of a search (i.e. diversification) phase, all suppliers are tested independently of their initial quality draw. This corollary can be used to sharpen our test of the model's base prediction. To do this, we replace first differences in unit values as a regressor by two interaction terms defining two distinct regimes. In regime 1 (concentration), first differences in unit values are interacted with a dummy equal to one if concentration is rising ($\Delta T_{kt} > 0$).

In regime 2 (diversification), first differences in unit values are interacted with a dummy equal to one if concentration is rising ($\Delta T_{kt} < 0$). Table 6 gives regression results for this test and a variant where the regimes are restricted to $\Delta T_{kt} > 0.1$ and $\Delta T_{kt} < 0.1$ respectively.

The first two columns of Table 6 confirm the model's base prediction. Positive year-on-year changes in the Theil index correlate with positive changes in unit values, and this result holds for a large set of fixed effects. That is, when there is re-concentration, it takes place on higher-quality suppliers. As shown in columns (3) and (4), this positive impact becomes stronger when restricted to deeper re-concentration phases, i.e. for phases where first differences in Theil are over 0.1 (this threshold corresponds to the top 25% of the re-concentration phases in terms of ΔT_{kt}). Strikingly, no significant correlation is found in diversification phases. We tested the robustness of this result by running the same estimation using the numbers of partners as the dependent variable. Results are similar to those presented here and are available upon request.

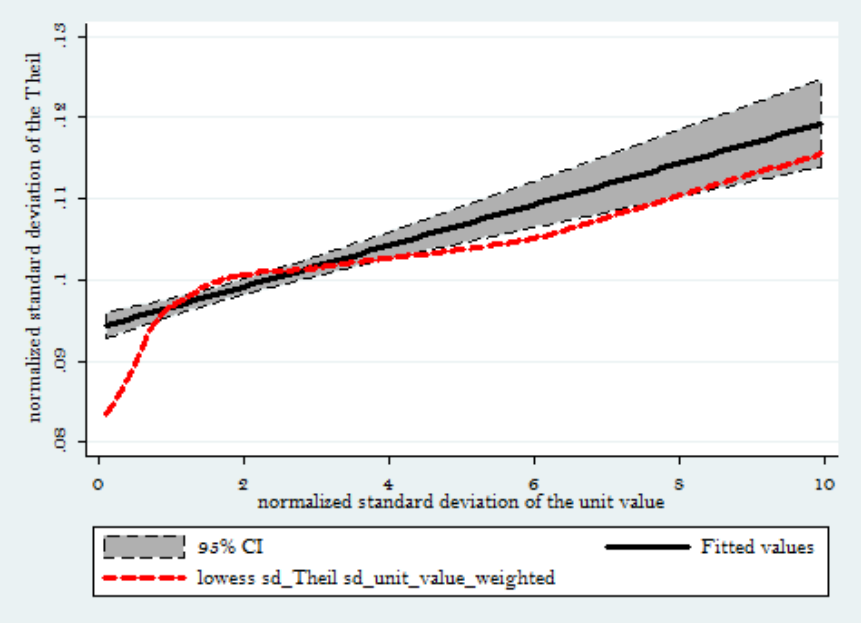
Finally, a similar regression using import-weighted averages of the exporters' GDP per capita instead of unit values gives a qualitatively similar result, suggesting that when re-concentration takes place, it is on suppliers located in higher-income countries, which tend to produce higher-quality goods (on this, see Hallak and Schott 2008). The evidence in Table 6 is thus suggestive of a quality-search process rather than a price-search one (in a price-search model, the search phase would settle on the lowest-price supplier).

We now turn to Proposition 2, which says that the alternating phases of quality screening and re-concentration will be more pronounced for products whose quality matters and where it is not standardized across suppliers. That is, the time-wise volatility of concentration should correlate with the dispersion of quality across suppliers. In order to test for this, we measure the time-wise volatility of concentration at the (importer × product) level by the normalized standard deviation of the Theil index over the entire sample period. We approximate the dispersion of quality across suppliers, also at the (importer × product) level, by the standard

deviation of unit values across time and exporters. Note that, in so doing, we reduce the sample's dimensionality from three (importer × product × time) to two (importer × product), i.e. we collapse our panel into a cross-section of (importer × product) pairs.

Before we turn to regression results, let us take a look at the relationship between the time-wise volatility of concentration and the variability of unit values for OECD imports as a whole (i.e. disregarding heterogeneity between importing countries). The plain line in Figure 7 is generated by regressing standard deviations of Theil indices on standard deviations of unit-values using pooled OLS with White-corrected standard errors.[12] The broken curve in the same figure is generated by running a "smoother" (non-parametric) regression instead of OLS. Non-parametric regression imposes no functional form and is therefore well suited to the exploration of data with no pre-determined relationship between variables.[13] Both show a positive relationship between the volatility of concentration over time (the amplitude of the alternating diversification/re-concentration phases) and the variability of unit values across time and suppliers (the extent of the selection problem).

Figure 7
Volatility of the Theil index versus volatility of import unit-value



[12] 95% confidence interval is also reported.
[13] Non-parametric "smoother" regression consists on re-estimating regression for overlapping samples centered on each observation.

We now turn to a parametric test exploiting cross-importer variation in our base relationship (although the time dimension of the panel is still collapsed by the construction of our volatility variables). In Table 7, the normalized standard errors of Theil and unit values are computed using both the whole sample (column 1) and the sub-sample of (importer × product) pairs with at least 30 non-missing observations over 1963-2006 (column 2). Results presented in Table 7 confirm the positive correlation between volatility in concentration indices and variability in product quality. As shown in columns 3 and 4, our results are also robust to the use of standard deviations in the numbers of partners as the dependent variable instead of standard deviations in Theil indices.

Table 7
Regression results, volatility of concentration on product quality heterogeneity

Dep. Var	σ_Theil_{ik}	σ_Theil_{ik}	σ_Nber_{ik}	σ_Nber_{ik}
Regressors	(1)	(2)	(3)	(4)
σ_UV_{ik}	1.63E-03 ***	1.02E-03 ***	1.75E-02 ***	1.01E-02 ***
	(2.28E-04)	*(2.27E-04)*	*(1.10E-03)*	*(1.02E-03)*
Observations *(ik)*	36,209	26,820	36,209	26,820
Nber of products *(k)*	1,299	1,299	1,299	1,299
Nber of importers *(i)*	29	29	29	29
Period	1963-2006	1963-2006	1963-2006	1963-2006
Importer Fixed Effects	Yes	Yes	Yes	Yes
Product fixed effects	Yes	Yes	Yes	Yes

Notes: estimation with OLS; standard errors in parentheses: heteroscedasticity consistent and adjusted for product-level clustering; * : p=0.1, **: p=0.05, ***: p=0.01.

Thus by and large, results are as suggested by the model. Re-concentration phases occur on goods of better quality and the volatility of concentration indices is higher for products with high quality heterogeneity. This indeed suggests alternating periods of diversification and concentration in search for quality.

6. Concluding remarks

Looking at the evolution of OECD imports at a high degree of disaggregation (over 1,000 product lines) over the 40-year period where data are available, we find striking evidence of geographical diversification at the product level. That is, OECD

countries have been sourcing each of their imported products from increasingly large pools of suppliers. We also find evidence of a geographical re-concentration of imports in the last five years or so, but this trend reversal is entirely attributable to the growing share of China in OECD imports. Put together with Besedes and Prusa's (2006a, 2006b) findings of high churning rates among exporters, our results suggest that OECD markets seem to be increasingly contestable for developing-country exporters, at least at the source-country level if not at the firm level.

As for the drivers of diversification vs. re-concentration, we find that when geographical concentration takes place, it tends to be on higher-priced national varieties. It is also more volatile for those goods which may be highly differentiated quality-wise where quality presumably matters more and is more heterogeneous across suppliers. Put together, these observations lend support to a model of quality search by OECD buyers generating alternating periods of concentration and diversification, discussed in section 2 of this paper. Our quality-search approach suggests that the contestability of OECD markets varies across time and products, with periods of closed doors, characterized by strong incumbency advantages, alternating with periods of open door, characterized by contestability. In terms of policy implications, our results highlight the importance of raising exporter quality-management capacities in developing countries, as periods of open door appear to be essentially periods of quality search.

References

Antras, Pol (2003), "Firms, Contracts, and Trade Structure"; Quarterly Journal of Economics 118, 1375-1418.

Barro, Robert J. and J.W. Lee (1993), International Comparisons of Educational Attainment, Journal of Monetary Economics, 32, pages 5-23.

Bas, Maria, and V. Strauss-Kahn (2011), "Does Importing More Inputs Raise Exports? Firm-level Evidence from France", mimeo, ESCP.

Besedes, Tibor, and T. Prusa (2006a), "Surviving the U.S. Import Market: The Role of Product Differentiation", Journal of International Economics 70, 339-358.

– and – (2006b), "Ins, Outs, and the Duration of Trade", Canadian Journal of Economics 39, 266-95.

Bikhchandani, Sushil; D. Hirshleifer, and I. Welch (1992), "A Theory of Fads, Fashion, Custom, and Cultural Change as Informational Cascades"; *Journal of Political Economy* 100, 992-1026.

Brenton, Paul, and R. Newfarmer (2007), "Watching More than the Discovery Channel: Export Cycles and Diversification in Development"; mimeo, The World Bank.

---, ---, and P. Walkenhorst (2007), "Export Diversification: A Policy Portfolio Approach"; paper prepared for the Growth Commission Conference on Development.

Broda, Christian, and D. Weinstein (2006), "Globalization and the Gains from Variety"; Quarterly Journal of Economics 121, 541-585.

Cadot, O, M. Shihotori and B. Tumurchudur (2008), "Revealed Factor Intensity Indices" ; mimeo, UNCTAD.

--, C. Carrère and V. Strauss-Kahn (2011), "Export Diversification: What's Behind the Hump?"; forthcoming, Review of Economics and Statistics.

Dutt, Pushan; I. Mihov and T. van Zandt (2008), "Trade Diversification and Economic Development"; mimeo, INSEAD.

Easterly, William, and A. Kray (2000), "Small States, Small Problems? Income, Growth, and Volatility in Small States"; World Development 28, 2013-2027.

--- and R. Levine (2001), "It's not Factor Accumulation: Stylized Facts and Growth Models"; World Bank Economic Review 15, 177-219.

Ethier, Wilfred (1982), "National and International Returns to Scale in the Modern Theory of International Trade"; American Economic Review 72, 389-405.

Evenett, Simon, and A. Venables (2002), "Export Growth in Developing Countries: Market Entry and Bilateral Trade Flows"; mimeo, 2002.

de Ferranti, David; G. Perry, D. Lederman and W. Maloney (2002); From Natural Resources to the Knowledge Economy; The World Bank.

Hallak, Juan Carlos, and P. Schott (2008), "Estimating Cross-Country Differences in Product Quality"; NBER working paper 13807; forthcoming, Quarterly Journal of Economics.

Hanson, Gordon (1996), "Localization Economies, Vertical Organization and Trade", American Economic Review 86, 1266-1278.

Hausmann, Ricardo; J. Hwang and D. Rodrik (2005), "What You Export Matters"; NBER working paper 11905.

-- and D. Rodrik (2003), "Economic Development as Self-Discovery"; Journal of Development Economics 72, 603-633.

Helpman, Elhanan; M. Melitz and Y. Rubinstein (2008), "Trading Partners and Trading Volumes"; Quarterly Journal of Economics 123, 441-487.

Hummels, David, and P. J. Klenow (2005), "The Variety and Quality of a Nation's Exports"; American Economic Review 95, 2005, 704-723.

Imbs, Jean, and R. Wacziarg (2003), "Stages of Diversification"; American Economic Review 93, 63-86.

Jansen, Marion (2004), "Income Volatility in Small and Developing Countries: Export Concentration Matters"; Discussion Paper #3, Research Dpt, World Trade Organization.

Jaud, Melise (2011), "Food Safety, Reputation, and Trade"; mimeo, Paris School of Economics.

Kee, Hiau Looi; A. Nicita and M. Olarreaga (2009), "Estimating trade restrictiveness indices"; Economic Journal 119, 172-199.

Klinger, Bailey, and D. Lederman (2004), "Discovery and Development: An Empirical Exploration of 'New' Products"; mimeo, The World Bank.

-- and – (2005), "Diversification, Innovation, and Imitation off the Global Technology Frontier"; mimeo, The World Bank.

Laeven, Luc, and E. Perotti (2001), "Confidence Building in Emerging Stock Markets"; CEPR discussion paper 3055.

Lederman, Daniel, and W. F. Maloney (2007); Natural resources: Neither curse nor destiny; Stanford: Stanford University Press.

Lutz, Mathias, and H. W. Singer (1994), "The Link Between Trade Openness and the Terms of Trade: An Empirical Investigation"; World Development 22: 1697-1709.

Shepherd, Ben (2008), "Geographical Diversification of Developing Country Exports"; MPRA paper 11267.

Appendix

The expression for the expected period-3 gain, as of the beginning of period 2, given that the buyer kept only one supplier, *x*, is

$$E\left(V_3|I_2\right)=q_2^x E\left(V_3|\zeta_2^x=1\right)+\left(1-q_2^x\right)E\left(V_3|\zeta_2^x=0\right) \qquad (17)$$

where the probability of no defect in period 2 given information at the beginning of period 2, q_2^x, is

$$q_2^x \equiv \Pr\left(\zeta_2^x=1|I_2\right)=p_2^x\lambda^G+\left(1-p_2^x\right)\lambda^B, \qquad (18)$$

and the expected gain in period 3 is

$$E\left(V_3|\zeta_2^x=1\right)=p_3^x\left(\zeta_2^x=1\right)\left(2\bar{\pi}^G\right)+\left[1-p_3^x\left(\zeta_2^x=1\right)\right]\left(2\bar{\pi}^B\right) \qquad (19)$$

given no defect in period 2 and

$$E\left(V_3|\zeta_2^x=0\right)=p_3^x\left(\zeta_2^x=0\right)\left(2\bar{\pi}^G\right)+\left[1-p_3^x\left(\zeta_2^x=0\right)\right]\left(2\bar{\pi}^B\right) \qquad (20)$$

given a defect in period 2. Finally, the probability of supplier *x* being of the good type is, by Bayes' rule,

$$p_3^x\left(\zeta_2^x=1\right)=\Pr\left(G|\zeta_2^x=1\right)=\frac{\lambda^G p_2^x}{\lambda^G p_2^x+\lambda^B\left(1-p_2^x\right)} \qquad (21)$$

given no defect in period 2 and

$$p_3^x\left(\zeta_2^x=0\right)=\Pr\left(G|\zeta_2^x=0\right)=\frac{\left(1-\lambda^G\right)p_2^x}{\left(1-\lambda^G\right)p_2^x+\left(1-\lambda^B\right)\left(1-p_2^x\right)} \qquad (22)$$

given a defect. Substituting these expressions into (17) and simplifying gives expression (10) in the text.